Making makers make maker machines

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Abstract

Fablab 2.0 is about enabling Fablabs as development platforms for new fabrication technologies. From this perspective, we have an obligation to become meta-reflective on our technology development - not just for immediate usability and transparency for users, but to push the frontiers of what is possible within the maker movement. In this paper we will explore selected cases of how Fablab RUC as a research Fablab develops new maker tools for students, researchers and entrepreneurs - and how they have become an important ingredient in staying vital for the overall discourse.

Keywords

Maker, Fab 2.0, Fablab, Maker machines, Academia, 3D printing, Robotics, Lego Construction, Education Teaching.

1 Introduction

When photocopiers first appeared they were considered highly advanced and expensive machines, requiring certified personell to operate them. Today photocopiers collect dust in dark rooms and are used - sporadically - by everyone. They are taken for granted and expected to work; the novelty is gone. We posit the same thing will happen with many of the machines found today in a Fablab. Most schools will soon have multiple 3D printers, a laser cutter and a variety of basic tools. They will be tools for everyday practice. In a way, the Fablab movement will have “won” at this point. It is therefore important to contemplate the wider social implications of the “Fab” revolution and the different potentials and scenarios it embodies for education, politics, design, commerce and everyday life (Haldrup, Hobye and Padfield 2016; Walter-Hermann and Büching 2013; Birchnell and Urry 2013; Gerschenfeldt 2005). We argue that the time has come to start exploring the potential of becoming meta-reflective on the future of Fablabs, specifically to focus on the potentials for pushing the concept of Fablabs forward. We posit that the core potential of Fablabs is to look beyond the current toolset and possibilities and start conversations about the future especially within the Fablab context itself.

Acknowledging that all design 'ontologically, phenomenologically, and as a professional practice - is indivisibly generative of futuring and defuturing' (Fry 2015: 420) we propose that rather than being just a matter of unbinding creation and creativity, design is an enterprise of exploring futures and the potential consequences and effects of designs; hence always inscribed into the process of 'futuring' and 'de-futuring' (ibid., see also Fry 2009). This prompts us to see see Fablabs as a means of exploring and experimenting with potential futures rather than simply building on existing designs in customized ways. Following Dunne and Raby (2013) we want to think about how digital fabrication generates speculations about potential futures - also the potential futures of Fablabs.

In this paper we look at some of the 'weak signals' we have observed through the years the Fablab has existed at Roskilde University. Through three cases we want to take an 'utopian gaze' on the potential of Fablabs viewing them as *DesignLabUtopias*; production sites for artifacts, props and conversation pieces enabling social fantasies about potential futures (Haldrup, Hobye, Samson & Padfield 2015). All cases are reproducible in a typical Fablab with laser cutter and CNC machines. These projects are examples of disrupting traditional power structures, e.g. enabling students to modify large robot arms with a hacksaw. All three examples carry futuring/defuturing potentials with them; hence are instructive as 'conversation pieces' to explore the potential futures of society, the Fablab and the Fablab within society. The cases are either a proof-of-concept or a version 2.0 of a current piece of design, but engage critically with the world to open up potentials.

2 Case #1 What if one could 3D print a whole house?

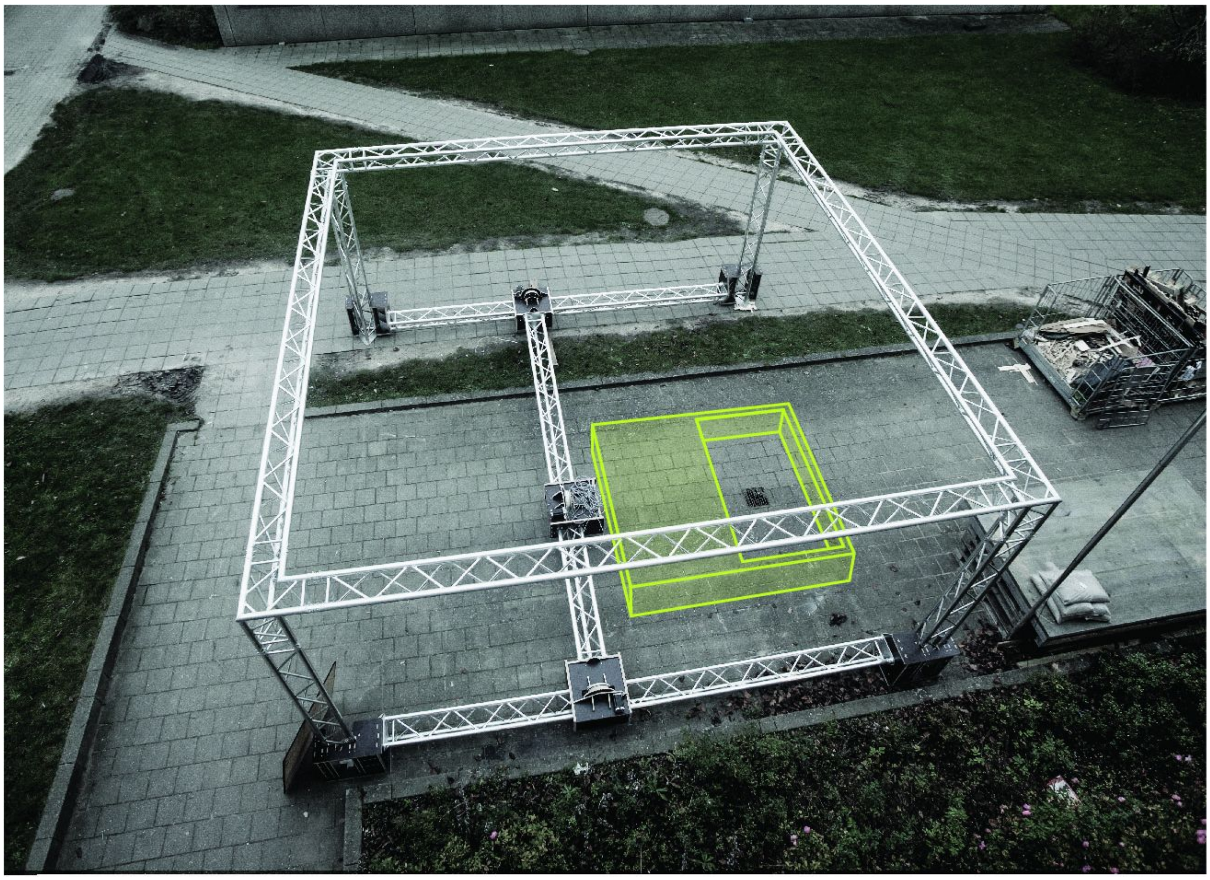

Figure 1: Picture of the 3D printer from above.

One thing is to have a line of standard desktop sized extruded plastic 3D printers at your disposal. For makers they are important and interesting tools to explore complex physical 3D shapes. But as a conversation starter they had become merely recognizable examples of what is already possible. To push this conversation forward we decided to construct project Mimir - a 3D printer that is able to 3D print houses, and prove that it could be done with a limited budget. Building construction today is often based on prefabricated concrete parts which are assembled into house constructions. Large scale 3D printing strategies may enable us to move beyond this paradigm and start construction of more free-form, one of a kind constructions. Previous large-scale 3D printing proposals have romanticized the ideals of fast, eco-friendly, custom manufacturing of houses. With Mimir we explore the feasibility of this potential. Is it a romantic dream for the future or is it actually feasible to 3D print constructions this size, now, on a budget?

Within 3 months and with a budget of merely $1100 the first prototype was made. It is 6x6x6m. Without the rapid prototyping machinery and the skilled competences within the environment it would not have been possible to design and build the printer within such a short period. This rapid and cheap manufacturing process enabled us to iterate multiple solutions to challenges. The printer was built with the standard truss system normally used for stage lightning, and the carriages are cnc milled out of water resistant plywood and rolles skate wheels/ball bearings. Within a month a working 6x6x6 XYZ machine was constructed. In the spirit of the maker movement and the Fablab charter all the diagrams and the material are open sourced for other Fablabs to reproduce. The printer itself is built with readily available Fablab tools like CNC milling and easily available parts like stepper motors, roller skate wheels and truss used for stage lighting. This enables other Fablabs and designers to build upon the work.

Figure 2: First experiments with the 3D printer printing concrete.

When the machine could move around in in XYZ space it became clear that we were only halfway there. As is common, the last 20% of the project takes 80% of the time. We had yet to figure out how to handle the concrete, nozzle, pumping system, how to deal with the material properties of concrete and how to achieve nice looking sides. We are still experimenting with this; so far the system has not yet actually built a larger structure. In some sense this is a failure or at least we have not gotten the major success yet. But as we look through the process, multiple side effects have appeared that are just as valuable as actually producing a working house. Building such a large device became a generative physical experiment as well as a thought experiment.

Thousands of questions started to appear as we were building it. Could a large scale 3D printer actually prove itself as a construction technique with new potentials? What material can be used? Could it be used to 3D print large concrete parts on site? Could it through the 3D printing technique be possible to construct individual appearances for parts of a house or differentaiate houses with the same base structure? Could a 3D printer become a way to build in extreme situations - on Mars, after disasters etc.? Could composite constructions consisting of multiple types of material (i.e structural/insulation) be constructed?

The computer controlled build process would enable new qualities that are not possible with traditional mold based forms. Through the project we simply wanted to create a platform to start understanding the possibility space. One could have chosen to have a conceptual and academic conversation instead of actually building the prototype, but through the build process it became clear how the physical prototype became an integrated part of the reflection process and informed it. It was only after “concrete” experience with nozzle design that both possibilities and limitations became clear. While many experts would have been able to forsee the challenges, the Fablab mentality gave the impetus, possibility and can-do attitude necessary to actually build the machine, something the concrete industry has not yet done in our part of the world.

In parallel we started to experiment with computationally generated intricate constructions and convert them into physical form. E.g. the rather complex beehive pattern below does not have a repeatable pattern, but can be a combination of unique shapes which results in a square. When 3D printed this could be turned into a lightweight custom structure like a wall element.

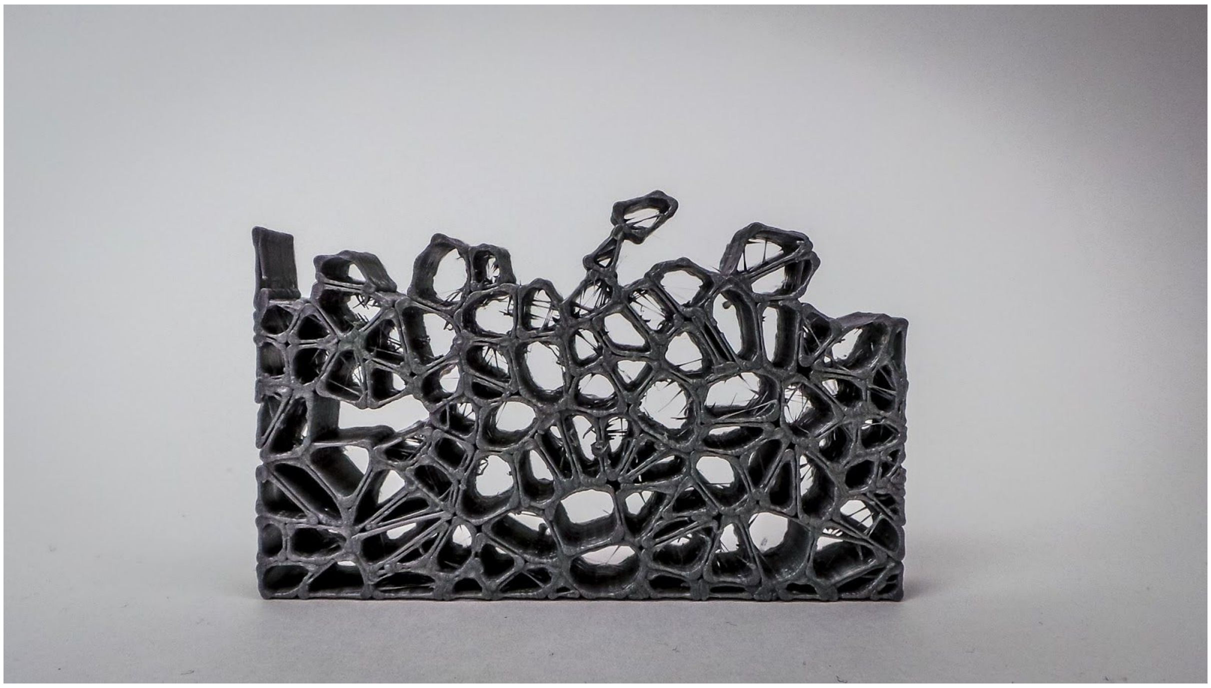

Figure 3: Computationally generated beehive pattern 3D printed in PLA as a prototype for new structures in concrete

People started to come into our lab to have conversations with us about the large object outside. They wanted to know what it was for and whether they could use it to build things they wanted to construct. Before we even had seen the slightest outcome of the 3D printer it had a role in the community. Large newspapers and tv stations would contact us about and the traditionally humanistic university was ahead in the game of technological advancement. Only a few experiments with this type of 3D printing have already been conducted for various construction purposes around the world. By building our own 3D printer we seeked to contribute to this design experimentation.

After the initial tests - the first “hello world” - it became clear that we were only 80% done. The XYZ movement was working perfectly and could be controlled with standard G-code, but we still had the tedious process of actually running multiple large scale construction jobs with concrete to really access the outcome and potential. One obstacle is the knowledge of how a failed 3D print looks on a small 3D printer and fearing to face a house sized version of it. It was clear that the last 20% would require just as much work as the first 80% of the build. It is also clear that 3D printing houses is possible and will be the state of the art within years, not decades. It is clear that the interest amongst users for having access to a working large scale 3D printer was huge. It is clear that society, media etc. are inspired by the theoretical possibilities.

3 Case #2 What if one could use a hacksaw to customize your industrial Robot Arm?

Figure 4: Our robot arm made entirely on Fablab machinery.

Robotic arms have historically been used mainly in industry, and were only economically viable in situations where a large number of repetitive tasks could be automated, many hours a day. Reliability and precision have been important as the indirect costs of failures could be huge. Robots have not been economically feasible for small businesses such as your local baker. The idea of students, tinkerers, fabbers having ubiquitous access their own, full size robot arm has been unnatainable - the idea of it being cheap enough that they can modify it at will has been even more unattainable. We wanted to democratise access to robots - similar to what Open Source has done for software or Arduino and Raspberry Pi for Open Hardware, we have created an Open Source industrial robot.

With fab methods, we thought it should be possible to enable widespread construction of cheap robot arms. Use existing Fablab machines to create the next Fablab machine. By selecting materials and processes possible at most Fablabs, we proved it was possible to make a full size robot arm, able to lift 5 kg, for a twentieth of the price of a professional, commercial offering.

We published Open Source plans on the internet, and accepted limitations and flak for the tradeoffs involved in making sure this robot could be replicated at most Fablabs worldwide. For example, we have access to a metal laser cutter, but made parts out of plywood and nylon - even though this makes the robot less stiff and precise - to ensure that anyone with access to standard Fablab tools could build one. The electronics parts can be bought for $750 on ebay. It takes about a day to build the robot.

We produced five robots for our students to explore and held a two week workshop. The low price of the robots gave students freedom to hack - even with a hacksaw. We did not have to worry, any piece modified could easily be replaced. The low price and reproducibility meant each small group of students had their own robot to hack, instead of having to book time on a shared, expensive robot. The whole toolchain was open source, removing software licensing issues as well.

Figure 5: Robot build by another Fablab/makerspace “Vrkstedet”.

A few weeks later, the image above appeared in our Facebook news feed. We were at first confused because it was clearly our robot, but the context was not recognizable. We quickly realised that people had downloaded the drawings and had replicated our industrial arm. Without any effort from our side that arm now existed in another physical location. This was one of many.

The robot has served its purpose - on multiple levels. It lets our students hack. It showed that an open sourced fab tool - even a slightly larger, more ambitious one - will be quickly re-created at other Fablabs worldwide. It created significant public debate about what a robot is, can do, should be - with engineers criticising safety, legal and technical issues in the new world of fab robots. It challenged traditional paradigm and praxis about access to technology and was a conversation starter on access to technology.

4 Case #3 What if one could make cheap hackable construction systems?

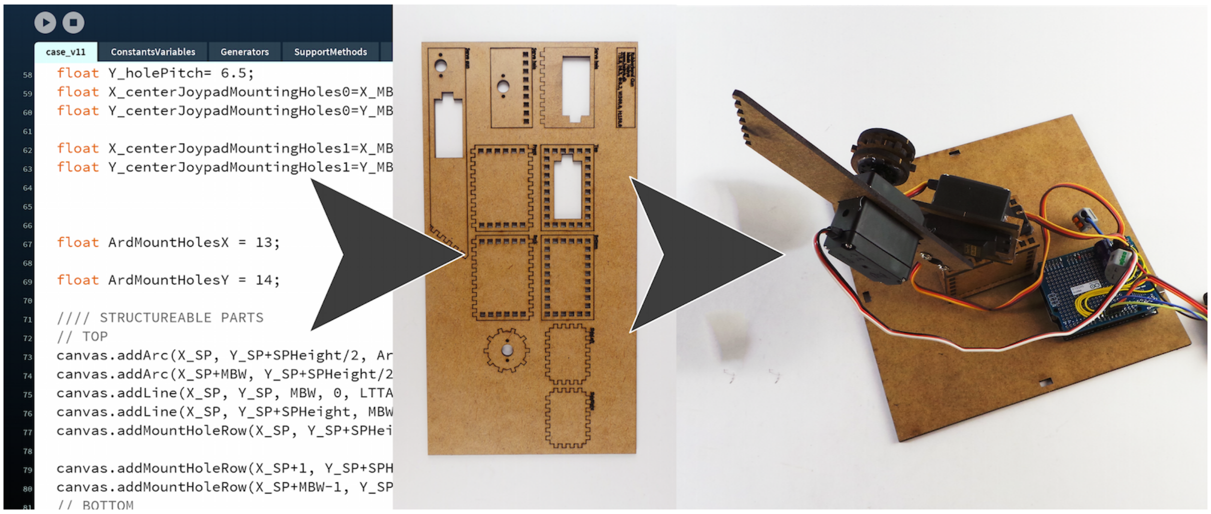

Figure 6: The toolchain of FabMaker. Experienced developers write code that generates "lego"-like pieces that can be combined in endless ways.

An underlying value in the Fablab movement is to enable users to use rather complex machinery. To eg. make it simpler to do the contouring when preparing the drawing for CNC milling etc. This is a valuable cause, but we have also experimented with the potential of using the Fablab machinery to make simplified tools for rapid prototyping. One such experiment is the FabMaker (fabmaker.hobye.dk) system. The system embodies the inherent qualities of Lego, Meccano etc. The core quality is the ability to have a set of generic pieces that can be combined in endless ways with little effort. The possibility space is up to the creator himself to imagine. The challenge is to design pieces which open up possibilities instead of having a fixed purpose. We set out to ask ourselves how this quality can be implemented in a maker environment. Lego is an obvious choice to use in itself, but the high price for pieces prevented them from being hackable. You do not cut your lego pieces in half and when class is done you are supposed to take your pieces apart and sort them into the proper piles so they are ready for the next person. To move beyond these limitation we invented the Fabmaker system.

At its core the FabMaker system consists of a software program in which one can design pieces with generic holes and edges. This enables the pieces to snap together on all sides and in all combinations. Using the software with university students, we have design multiple elements with different properties. The pieces are been collected on one single sheet that can be cut from HDF on a laser cutter. This means a single sheet of HDF can be laser cut into a rather complex prototyping kit for students, researchers etc. The kit is designed to play well with Arduino components (servos, buttons etc.). This kit thus becomes the physical side of prototyping with Arduino.

This allows us to start rather advanced ideation and prototyping without having to use the more advanced machines for the actual prototyping. As long as we have lasercut the generic sheet we can use the pieces to design endless prototypes. A technically skilled workshop holder is thus able to prepare the sheets and novice users can engage without having to learn to eg. draw complex 2D or 3D shapes. The users of the system only need to focus on their idea

and only need to know how to use a gluegun. They are even allowed to hack the pieces as much as they want to. They can cut a corner off or turn the pieces into something entirely different, because the pieces are so inexpensive that they do not necessarily have to be reused at a later point.

Beyond the system embedding some core qualities of the maker movement, it also opens up the possibility space for novice users to have their first success with prototyping and making. Instead of being technically specialized they can be people engaged in specific praxises that want to redesign it themselves.

We have used it for the Academy for Talented Youth (especially talented high school students from across the country) to get a one day taste of what it means to prototype in physical materials. Within a day they are able to construct highly individual robotic projects with multiple moving parts that they themselves program to react to their surroundings. Their creative joy and feeling of being successful is beyond what a workshop holder could wish for.

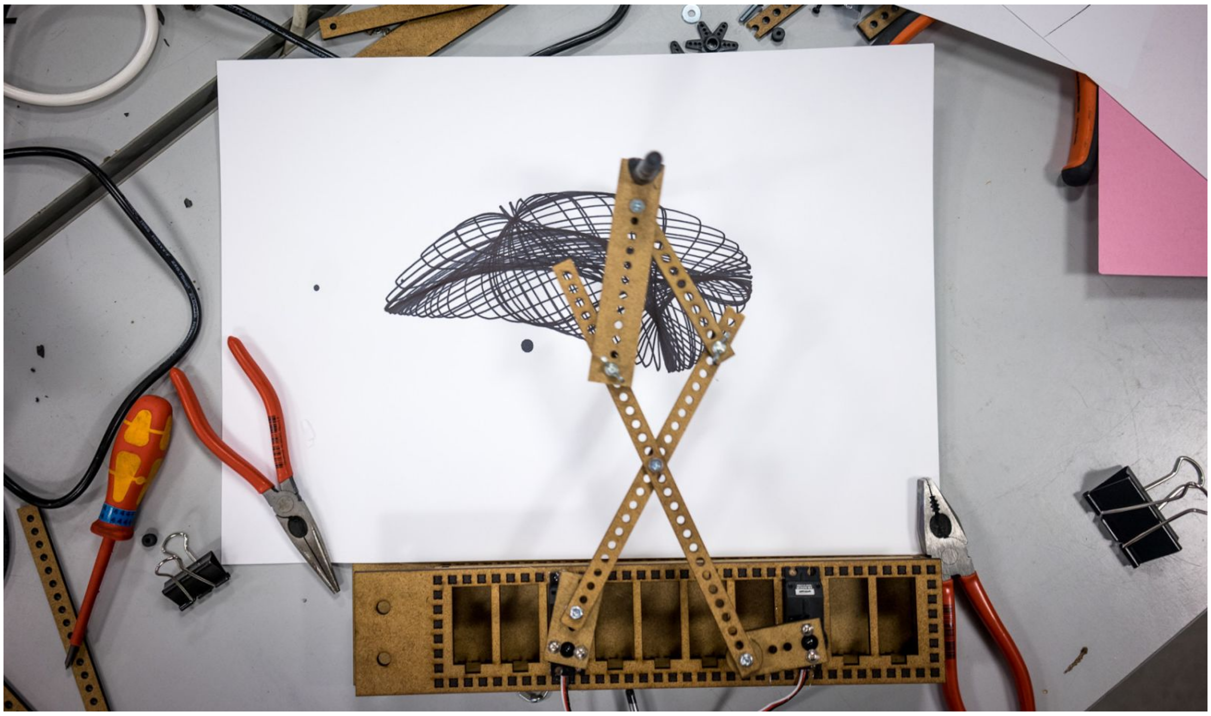

Figure 7: Example of a drawing machine made with the FabMaker kit.

5 Conclusion: Making makers make maker machines

The reviewed selected cases show an inkling of the potential of the Fablab. One thing is to build small prototypes with outside potential, but it has become apparent in our cases that making machines with new making potential is quite feasible and seems to be extremely generative and a way to push forward the potential of Fablabs. Additionally this has the potential to keep the Fablab concept alive and well - avoiding becoming the dusty copy machine room. The core takeaways from our cases are as follows:

Making maker machines points towards future potentials in which rapid prototypes initiate a conversation around the potentials of the machines themselves and how to push the Fablab movement forward. It is crucial to open up the conversation with stakeholders and other Fablabs through open sourcing the designs and documenting the build process. One can posit that the imperfection and unfinishedness of the machines allows for even more open conversations and freedom to hack than super finished products would. By “publishing early, publishing often” we have integrated the public in the ongoing conversations. As demonstrated by the examples on display here, the very process of experimentation and exploration of potentials with fully functioning prototypes of ‘future machinery’ enables also non-experts to take part in explorative imaginations, testing and even actual experiences with advanced forms of ‘making’. Moreover, our experience also shows that the Fablab machinery has proven that it is also possible (with a little ingenuity) to start ambitious projects on a low budget, and actually design and build ‘products’ that are workable and functional. This has enabled access to technology conversations that would previously have been reserved for large corporations or well funded university projects. It should not be underestimated that 80% of the work is in the last 20% percent of the project. However, the project only needs to work 80% to enable conversation and exploration of possibilities.

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